6.2.2 Biohazards

Appropriate biohazard training should be provided as required by Federal and State OSHA regulations and/or recommended by specific health agencies such as the National Institutes of Health (NIH) and the Centers for Disease Control (CDC). It is recommended that biohazard training for medical waste treatment personnel be consistent with training outlined in the OSHA final rule on Occupational Exposure to Bloodborne Pathogens (OSHA, 1992).

Medical waste handlers, treatment operators, and supervisors should be trained in issues relevant to preventing biohazard exposure.

6.2.3 Incinerator Operator Safety Training

It is important that operators are aware of safe practices for incineration. Safety practices should be considered for waste feed handling, incinerator operation, and ash removal from the incinerator. For each of these activities, safety gear should be worn, including rubber soled shoes, rubber gloves and safety glasses. Respirators and hearing protection should also be used during maintenance of fabric filters.

Certain practices should be routine when handling waste feed. To minimize the chance of exposure to infectious agents, medical waste is placed in tear-resistant bags or other containers which meet applicable regulations. Sharps (needles, tools) should be placed in rigid containers. If tears or holes are noted, the bag should be placed in another bag or container. Waste handling should be minimized by use of carts for transport onsite. Disposable containers can be loaded into the incinerator either manually or automatically. Devices that could increase chances of bag rupture, including trash compactors, dumb-waiters, chutes or conveyors for transport, should not be used. To minimize fire and potential health hazards from vermin attracted to the waste, waste feed should be stored in a restricted-access area away from the incinerator and treated as soon as possible after generation.

During incinerator operation, fire safety should be paramount. Containers of flammable liquid or explosives should never be charged to the incinerator. The primary chamber burner should be off when waste is added. Manually loaded incinerators usually have an interlock system that automatically turns off the burner when the charging door is opened. Most automatic loaders will spray water on the hot ram face or reinitiate loading if waste is burning.

Standard procedures should also be followed when ash is removed from the incinerator. Ash should not be removed until after the cooldown period which may be as long as 8 hours. Entrainment of ash particles can be minimized by slowly opening the ash cleanout door and quenching the ash with water once it is removed from the incinerator. Ash

should always be handled cautiously because it may contain buried sharps, hot spots and may aerosolize easily.

6.3 SUPERVISION

Medical waste treatment operators should be under the supervision of an adequately trained professional who assumes and carries out responsibility for the operators' performance, health, and safety.

6.4 HEALTH SURVEILLANCE AND IMMUNIZATION

Health surveillance and immunization practices should be consistent with the OSHA final rule on Occupational Exposure to Bloodborne Pathogens. An employer should assure that all evaluations, procedures, immunizations, and post-exposure management are provided to the medical waste worker at a reasonable time and place, and according to standard recommendations for medical practice.

It is recommended that all medical waste treatment personnel be immunized against the hepatitis B virus (HBV). Other immunizations may also be appropriate if it is known that the medical waste to be treated routinely contains a pathological agent for which an approved vaccine is available.

6.5 PERSONAL PROTECTIVE EQUIPMENT

Personal protective equipment is recommended to significantly reduce worker exposure during the transport, handling, and processing of untreated medical waste regardless of treatment technology. This includes the use of appropriate puncture-proof gloves, safety glasses or faceshields, protective and non-slip footwear, fluid-resistant protective clothing, and respirators as required. Hearing protection may be indicated for operations that grind or shred waste prior to treatment. Blunt tools may be necessary to assist in the waste loading process, and are recommended to discourage hand-to-waste contact.

7.0 FACILITY MAINTENANCE

7.1 GENERAL REQUIREMENTS FOR ALL TECHNOLOGIES

It is recommended that any person or organization using medical waste treatment technology be familiar with it and conform to the manufacturer's specifications for the start-up, use, maintenance, limitations of the equipment, and use the equipment in a manner consistent with any Federal, State, or local governmental regulations concerning medical waste treatment and disposal.

A qualified maintenance technician should be available to service the medical waste treatment system by making adjustments or repairs, or conducting routine preventive maintenance. Either the manufacturer, a contractor, or health care facility employee may be retained to provide regularly scheduled maintenance and emergency repair.

7.2 INCINERATION

Proper maintenance of incinerators and air pollution control devices is required. Good maintenance will prolong the service life of incinerator components, reduce downtime pollution, costly repairs.

The hospital maintenance department usually provides incinerator maintenance on a set schedule or by work order from the incinerator operator. The operator should make periodic inspections of the incinerator components. The inspections may be on an hourly, daily, weekly, biweekly, monthly, or semi-annual basis. The frequency of inspection depends on the particular component. A typical schedule for maintenance of a hospital waste incinerator is shown in Table 7.1. Careful recordkeeping is very important because it documents service history and shows performance trends.

7.2.1 Additional Maintenance Recommendations

Air pollution control devices also require careful maintenance. As with incinerators, the frequency with which these maintenance activities take place will depend on a number of variables including the size and complexity of the scrubber, the number of hours per day it operates, and the volume and pollutant concentration of the exhaust gas it handles. In addition, not all of the maintenance activities listed will be required at each scrubber installations. The type and frequency of maintenance activities will depend in large part on the scrubber vendor's recommendations and the experience of personnel with the unit.

Although the frequency and components of a preventive maintenance program for a fabric filter system will depend on the type of system and the vendor's recommendations, the major components should be inspected on a routine basis, and any needed maintenance should

Table 7.1 Typical Maintenance Schedule for a Medical Waste Incinerator

Activity Frequency	Incinerator Component	Procedure
Hourly	Ash removal conveyor	Inspect and clean as required
	Water quench pit	Inspect water level and fill as required
Daily	Opacity monitor	Check operation of the opacity monitor and check exhaust for visible emissions
	Oxygen monitor	Check operation of the oxygen monitor
	Thermocouples	Check operation of thermocouples
	Underfire air ports	Inspect and clean as required
	Limit switches	Inspect for freedom of operation and potential obstructing debris
Weekly	Door seals	Inspect for wear, closeness of fit, and air leakage
	Ash pit/internal dropout sump	Clean after each shift on batch units that do not have continuous ash conveyor cleaning system
	Heat recovery boiler tubes	Inspect and clean as required. (Clean weekly for 6 weeks to determine optimum cleaning schedule.)
	Blower intakes	Inspect for accumulations of lint, debris; clean as required
	Burner flame rods (gas-fired units)	Inspect and clean as required
	U. V. scanner flame sensors	Inspect and clean as required
	Swing latches and hinges	Lubricate
	Hopper door support pins	Lubricate
	Ram feeder carriage wheels	Lubricate
	Heat recovery induced-draft fans	Inspect and clean fan housing as required. Check for corrosion and V-belt drives and chains for tension and wear.
Biweekly	Hydraulic systems	Check hydraulic fluid level and add the Proper replacement fluid as required. Investigate sources of fluid leakage.

Table 7.1 Typical Maintenance Schedule for a Medical Waste Incinerator (continued)

Activity Frequency	Incinerator Component	Procedure
Biweekly (continued)	Ash removal conveyor bearings	Lubricate
	Fuel trains and burners	Inspect and clean as required. Investigate sources of fuel leakage as required
	Control panels	Inspect and clean as required. Keep panel securely closed and free of dirt to prevent electrical malfunction.
Monthly	External surface of incinerator and stack	Inspect external "hot" surfaces. White spots or discoloration may indicate loss of refractory
	Refractory	Inspect and repair minor wear areas with plastic refractory material
	Internal ram faces	Inspect for wear, These stainless steel faces may wear out and may require replacement in 1 to 5 years depending on service
	Upper/secondary combustion chamber	Inspect and vacuum any particulate matter that has accumulated on the chamber floor
	Large combustion air blowers and heat recovery induced draft fans (those fans whose bearings are not sealed)	Lubricate
Semi-annually	Hydraulic cylinder clevis and trunnion attachments to all moving components	Lubricate
	Burner pilots	Inspect and adjust as required
	Hot external surfaces	Inspect and paint with high-temperature paint as required
	Ambient external surfaced	Inspect and paint with equipment enamel as required
	Chains	Inspect and brush clean as required. Lubricate

Source: U.S. Environmental Protection Agency. 1989. Operation and Maintenance of Hospital Medical Waste Incinerators. Research Triangle Park, NC: Control Technology Center. EPA publication no. 450/3-89-002.

be performed. A specific preventive maintenance program should be established based on the manufacturer's recommendations.

7.3 STEAM AUTOCLAVE TREATMENT SYSTEMS

Steam autoclave treatment systems should be serviced according to the maintenance schedule recommended by the manufacturer. While the types of systems vary widely, many similarities exist. All autoclaves have a tightly sealed treatment chamber and drains that must be cleaned and inspected on a regular basis. They all have temperature and pressure gauges used to monitor treatment parameters that must be validated. Steam supply lines and condensation lines are present in most systems. Table 7.2 presents a typical maintenance schedule for steam autoclave treatment systems.

7.3.1 Benchtop Autoclave

Benchtop steam autoclaves are distinguished from other types of autoclaves because they are not connected to an external steam supply. These autoclaves generate their own steam from water added at the beginning of each cycle. The manufacturers usually provide operators with information regarding the maintenance of the equipment with special attention to cleaning of the chamber and inspection of drain lines.

7.3.2 Standard Laboratory Autoclave

The standard laboratory autoclave is similar in size and operation to the benchtop autoclave, however, the laboratory autoclave usually has an external steam supply. Many of the maintenance concerns are the same as for the bench scale autoclave with the exception of steam generation and drainage system. Operational parameters and instrumentation are similar in most small systems and a similar maintenance schedule is suggested for these systems.

7.3.3 Prevacuum Autoclave

Prevacuum autoclave systems are large freestanding treatment units that are usually installed onsite at hospitals. They come in a variety of sizes to accommodate the needs of different sized facilities. All prevacuum autoclaves are equipped with an external vacuum supply and an external steam supply. Steam condensate is discharged directly to the sanitary sewer.

7.3.4 Large Gravity Displacement Autoclave

Large gravity displacement autoclaves are usually found in commercial waste treatment facilities because they can treat up to 3,000 pounds of waste per cycle. The steam is supplied by an external boiler. Most of the condensed exhaust steam is recirculated to the

Table 7.2 Typical Maintenance Schedule for a Steam Autoclave Medical Waste Treatment System

Activity Frequency	Autoclave Component	Procedure
Every cycle	Door seals	Inspect gaskets for signs of wear, leakage, and closeness of fit
Daily	Temperature monitor	Check operation of graphic temperature monitor and replace chart when necessary
Weekly	Steam lines	Inspect for obstructions or leaks and repair if necessary
	Sewer discharge lines	Inspect for obstructions or leaks Flush drains
Monthly	Autoclave chamber	Inspect. Clean and scrub if necessary.
Annually	Temperature gauge	Calibrate with NIST reference thermometer
	Pressure gauge	Calibrate and inspect for readings consistent with the temperature recordings.

boiler for reuse. Other residual steam condensate that cannot be recirculated is discharged directly to the sanitary sewer.

7.4 CHEMICAL MEDICAL WASTE TREATMENT SYSTEMS

Antimicrobial chemicals may be used alone or in combination with a mechanical destruction device such as a shredder or hammermill to treat and destroy medical waste. Treatment efficacy depends on the characteristics and concentration of the active ingredient and the contact time of the waste with the disinfectant. Mechanical/chemical treatment systems also render the waste unrecognizable. The entire treatment system must be maintained adequately to treat the waste most effectively. The manufacturers recommended specific maintenance requirements for each treatment system and the manufacturers' maintenance recommendations should be followed. The guidelines in the document are general recommendations for a minimum maintenance schedule. Table 7.3 presents a typical maintenance schedule for mechanical/chemical treatment systems.

7.4.1 Static Antimicrobial Chemical Treatment

Static antimicrobial chemical treatment processes include liquid treatment of medical waste in a container followed by disposal of the treated waste. It also may include chemical treatment of medical waste in a container followed by encapsulation. These systems require no mechanical maintenance because they have no moving parts. The concentration of the active ingredient in the solution, pH and contact time are the only parameters that affect treatment efficacy.

7.4.2 Recirculating Mechanical/Chemical Treatment Systems

Recirculating mechanical/chemical treatment systems include chemical microbial inactivation and mechanical destruction of medical waste. The antimicrobial solution in these systems is reused for more than one load of waste. The disinfectant solution may or may not be supplemented with additional active chemical ingredient with each waste load. The mechanical grinder/shredder/hammermill portions of the systems require maintenance attention on a regular basis. The manufacturers of these devices provide a recommended maintenance schedule which should be followed. These recommendations should be considered as minimal criteria in the absence of manufacturer's guidance.

7.4.3 Flow-Through Mechanical/Chemical Waste Treatment System

Flow-through mechanical/chemical treatment systems include chemical microbial inactivation and mechanical destruction of medical waste. These systems differ from the recirculating systems because the chemical solution is discharged directly to the sanitary sewer after a single use. These systems come in a variety of sizes and are applicable to many different sized facilities. The manufacturers of these devices provide a recommended

Table 7.3 Typical Maintenance Schedule for a Mechanical/Chemical Medical Waste Treatment System

Activity Frequency	Treatment System Component	Procedure
Hourly	Conveyor	Inspect
	Drain line	Inspect for free flow
Daily	Hammermill or grinder	Grease bearings
Weekly	Cabinet	Inspect and clean if required
Monthly	Drive belt	Check tension
	Ventilation	Check negative pressure with smoke test
Semi-annually	Compressor	Bleed moisture from filter Check pressure Check drive
	Air filtration system	Inspect
	Hoses and fittings	Inspect
	Valves	Check for leaks
	Hammermill bearings	Inspect and replace at least annually
	Hammers	Inspect and replace at least annually
	Chutes and gaskets	Inspect
	Metal parts	Spray corrosion preventative where necessary

maintenance schedule which should be followed. The recommendations in this guidance document should be considered as minimal criteria in the absence of manufacturer's guidance.

7.5 NONIONIZING RADIATION TREATMENT SYSTEMS

Nonionizing radiation treatment systems destroy microorganisms by thermal inactivation. The treatment systems may include mechanical destruction. The grinding and shredding of the waste increases the uniformity of the waste as well as meeting the destruction definition in 40CFR Part 259. These treatment technologies are relatively new and for that reason the manufacturer provides extensive guidance with regard to maintenance schedules and requirements. The guidance in this document should be considered supplemental minimal requirements to the manufacturers' recommendations.

7.5.1 Microwave Systems

Microwave treatment of medical waste includes a preliminary waste grinding and shredding phase that meets the destruction criteria of the MWTA and makes the waste more homogeneous in nature. The waste is then sprayed with steam to increase the moisture content of the waste to ~10 percent to increase the microwave heating of the waste. The moist waste is then transported by screw auger past 6 microwave generators that heat the waste to inactivate microorganisms. The treated waste is then collected in a roll-off waste container for transportation to the sanitary landfill where permitted by local authorities. The manufacturer provides guidance for maintaining the entire treatment system and these recommendations should be considered supplementary to them. Table 7.4 presents a typical maintenance schedule for microwave treatment systems.

7.5.2 Shortwave Radiofrequency Systems

Shortwave radiofrequency treatment of medical waste includes a preliminary waste grinding and shredding phase that meets the destruction criteria of the MWTA and makes the waste more homogeneous in nature. The waste is then sprayed with water to increase the moisture content of the waste to ~10 percent to increase the radiofrequency (RF) heating of the waste. The moist waste is then packed into large insulated polyethylene treatment containers and transported by conveyor belt through an RF generating tunnel where the waste is heated to inactivate microorganisms. The manufacturer provides guidance for maintaining the entire treatment system and these recommendations should be considered supplementary to them. Table 7.5 presents a typical maintenance schedule for a shortwave radiofrequency medical waste treatment system.